How to Create Stream-Smart Crossings

The Golden Rule:
Let the stream act like a stream

Stream-Smart Options

1) **Avoid creating a crossing**
2) **Remove** the crossing
3) **Open bottom** structure that spans or exceeds channel
   - Abutments for temporary bridge
   - Bridge
   - Arch culvert
   - 3-sided box culvert
4) **Embedded** culvert
5) **Hydraulic designs**

Open bottom structures

Temporary Bridge Deck

Bridge

Bottomless Box Culvert

Arch Culvert

Embedded pipes

Embedded box culvert

Liners don't achieve stream-smart outcomes!

Rules of Thumb (4 S's)

<u>Span the stream</u>

Set elevation right

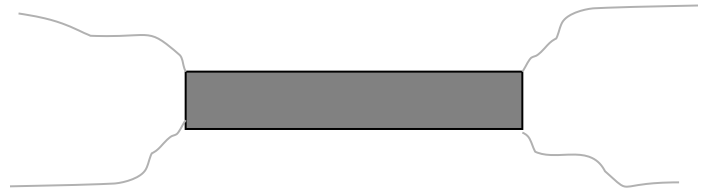
Slope matches stream

Substrate in the crossing

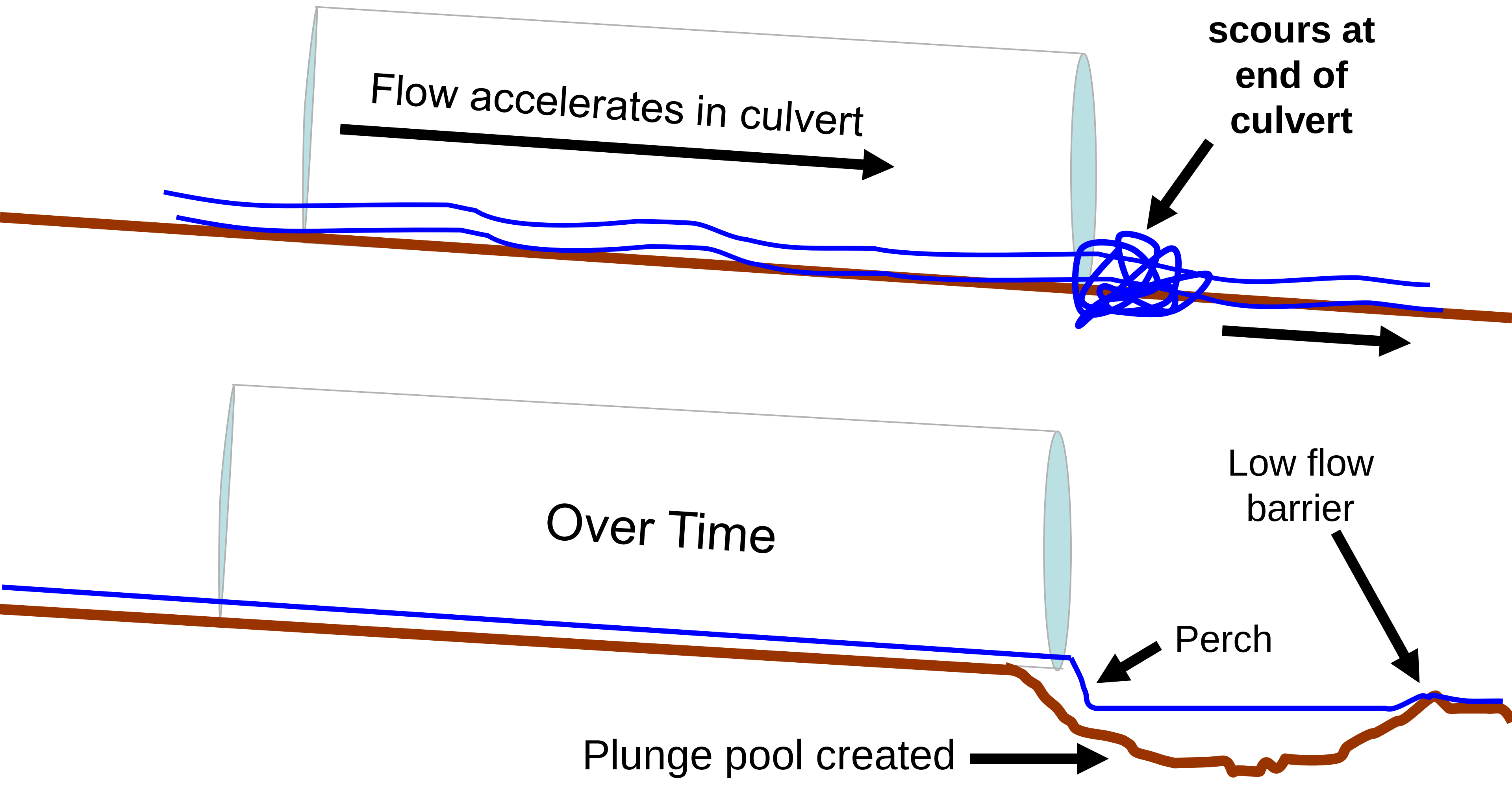
Don’t pinch the stream


Span the stream
(and exceed it where possible)

How undersized culverts constrict stream flow and become perched



Culvert that does not span the channel set at stream grade



Real World – Blanchard

2008

2010

Rules of Thumb (4 S's)

Span the stream

<u>Set elevation right</u>

<u>Slope matches stream</u>

<u>Substrate in the crossing</u>

Set elevation right

Indicators of elevation problems

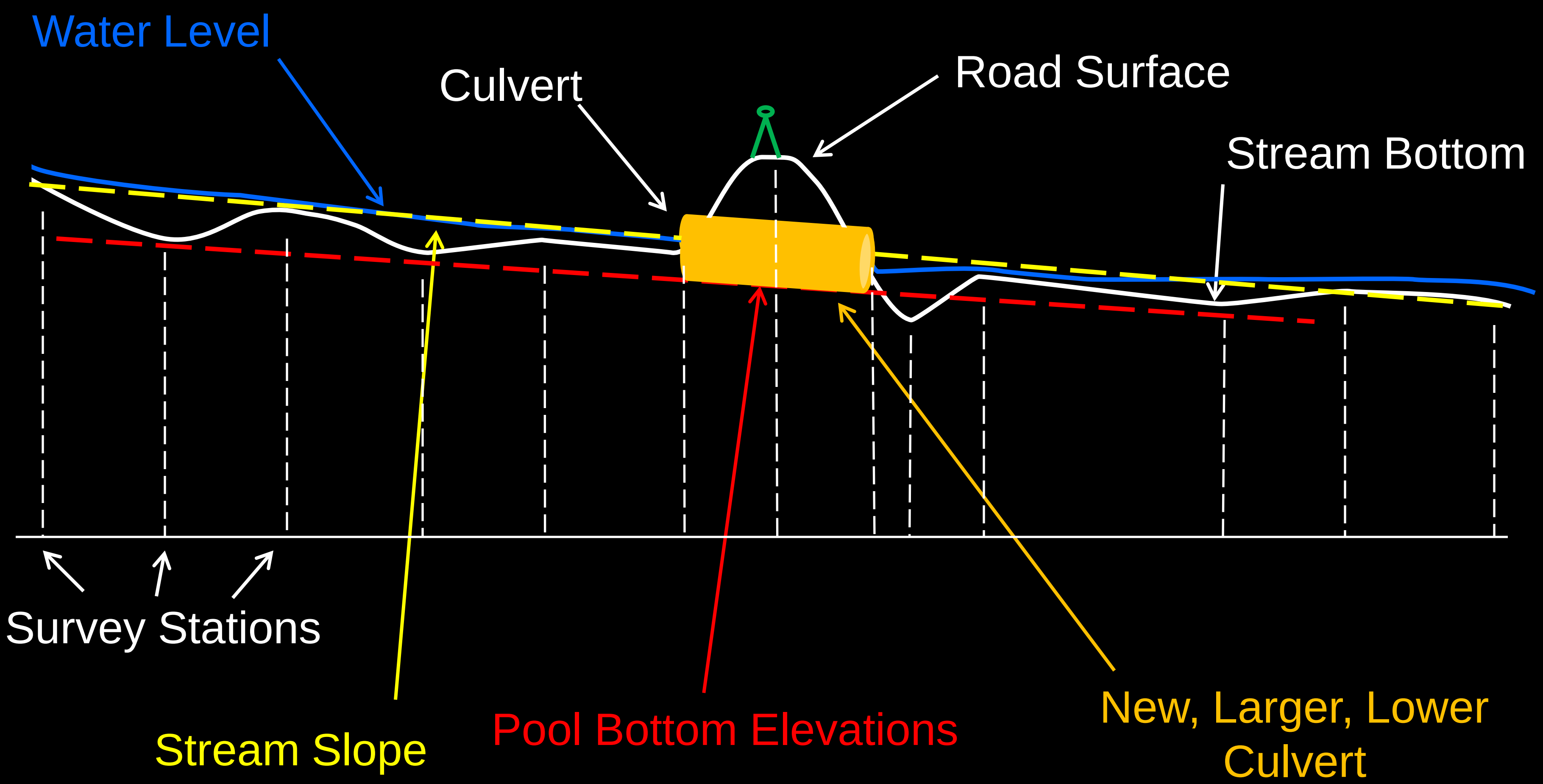
A stream channel rediscovered!

Indicators of correct elevation

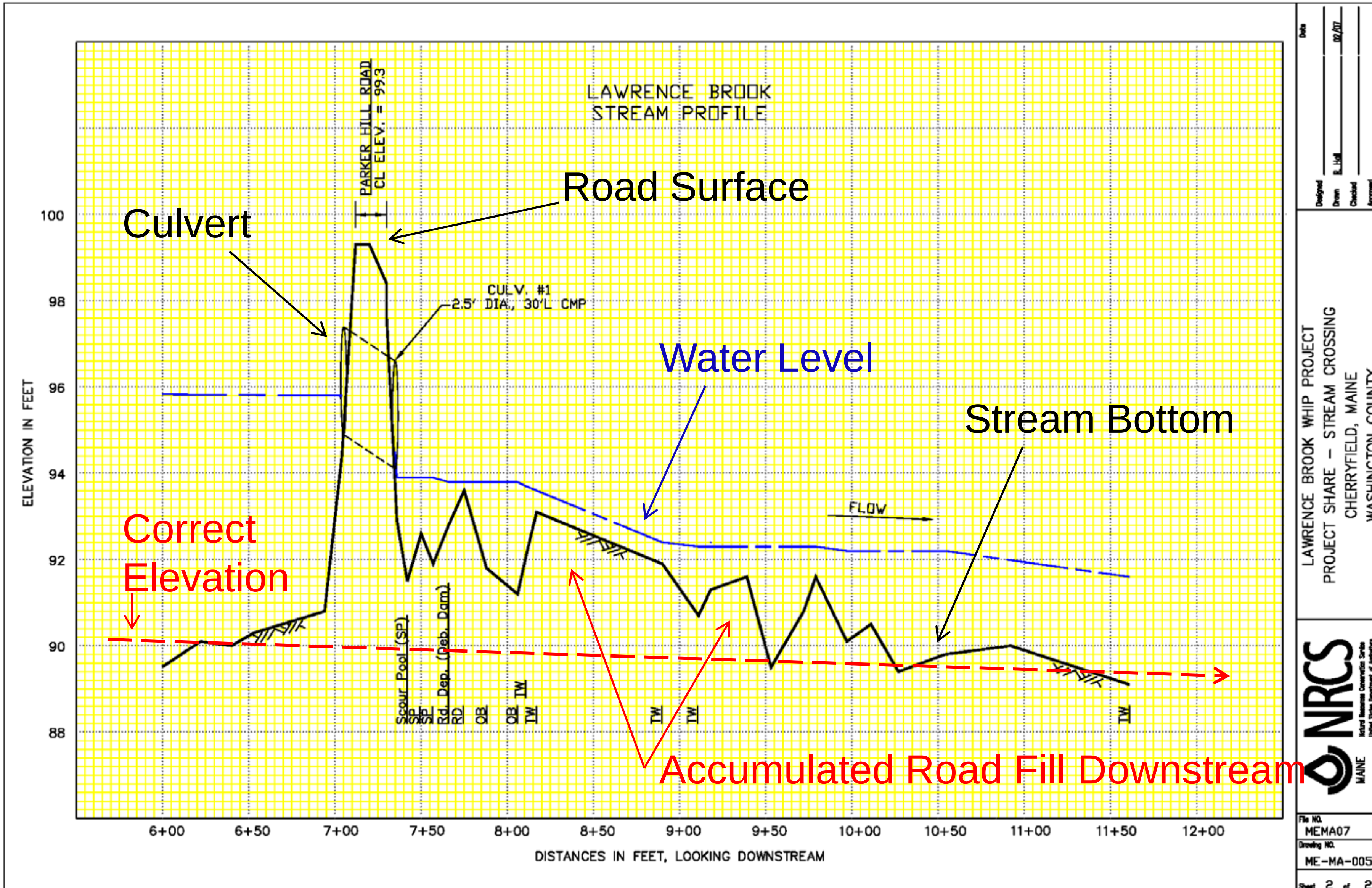
Seamless inlets and outlets

Longitudinal Profile

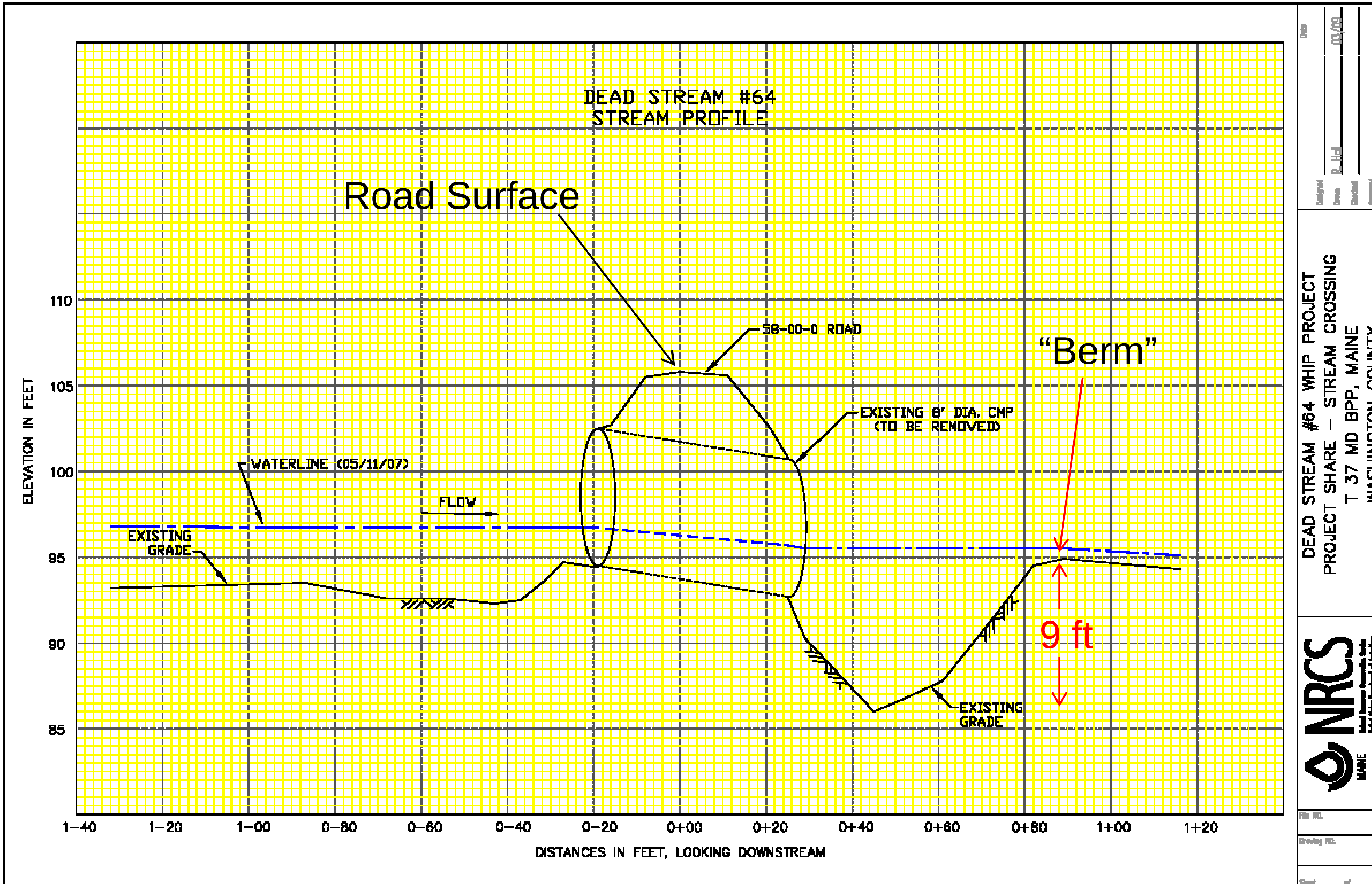
Used to find correct elevation and slope



Longitudinal Profile Example 1



Longitudinal Profile Example 2



Substrate in the crossing

Stream-Smart Sizing

Step 1: Planning

- Flow Volume
- Species of concern

Step 2: Sizing

- For spanning stream and Flow
  - Field Method
  - Hydrologic Method

Step 1 (For Sizing)

- What volume of flow are we allowing for?

  25-, 50-, 100- or 150-year storm event?

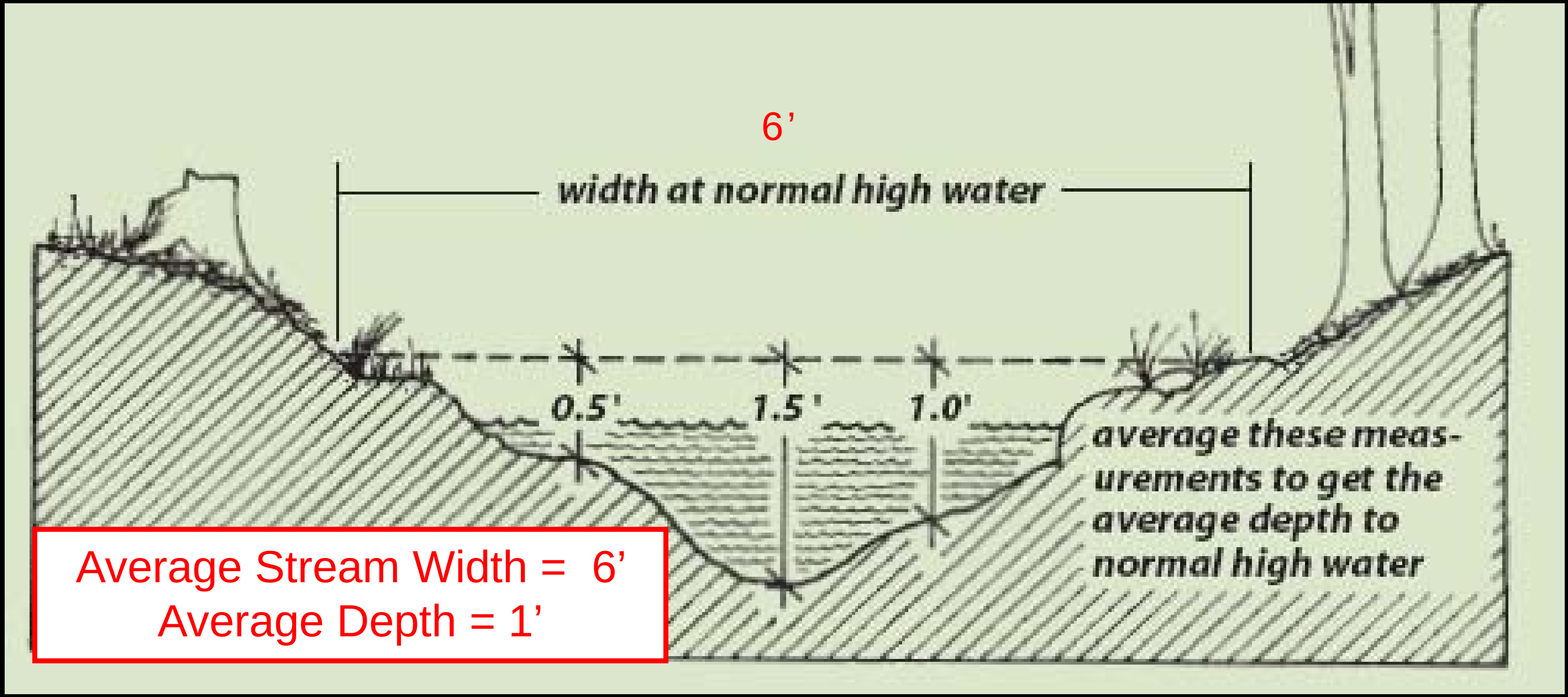
- What species are we concerned about?

  Fish, amphibians, mammals, invertebrates?

Step 2: Field Method

Determine the Opening size needed

Measure both upstream and downstream of crossing in an undisturbed location, and average measurements



Step 2: Hydrologic Method

25-yr 14'1" X 6'2" X 28' CM Box Culvert

Frequency yrs	Discharge cfs	Elevation ft	Velocity[1] ft/sec
10	130	87.6	2.7
25	200	88.5	3.3

[1] Velocity through culvert opening.

Tip: In most situations the width of the opening for a bridge or culvert should be at least as wide as the stream channel at normal high watermark. Sizing a crossing only based on the 10 or 25 year flood (see page 46-47) may not always accomplish this goal.

Step 2 (continued)

Design the crossing to meet the required opening size and account for embedding

Table C
Culvert Diameter and Opening Sizes

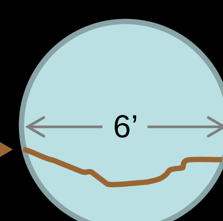
Opening size (sq. ft.)	Diameter (inches)
0.20	6
0.80	12
1.25	15
1.75	18
2.40	21
3.15	24
4.90	30
7.05	36
9.60	42
12.55	48
15.90	54
19.65	60
23.75	66
28.26	72

Stream-Smart Design:

3X cross section (25-year flood):
- ➔Stream width = 6 ft
- ➔Average stream depth = 1 ft
- ➔Opening size = 18 sq ft

Table C (Round Culverts):
- ➔Opening Size >= 18 sq ft = 23.75 sq ft
- ➔Culvert Diameter = 66 in
  - ➔* Less than stream width, so select next size up = 72 in

Allows Embedding (28.26 – 18 = 10.26 sq ft) up to 35% of opening size



Step 2 (continued)

Consider alternatives: Pipe Arch

Pipe Arch Equivalents

DIAMETER	EQUIV. ARCH SIZE
48"	53" x 41"
54"	60" x 46"
60'	66" x 51"
66"	73" x 55"
72"	81" x 59"
78"	87" x 63"
84"	95" x 67"
90"	103" x 71"
96"	112" x 75"
102"	117" x 79"
108"	128" x 83"
114"	137" x 87"
120"	142" x 91"
125"	150" x 96"
132"	157" x 101"
138"	164" x 105"
144"	171" x 110"

Stream-Smart Design:

3X cross section (25-year flood):

- Stream width = 6 ft
- Average stream depth = 1 ft
- Opening size = 18 sq ft

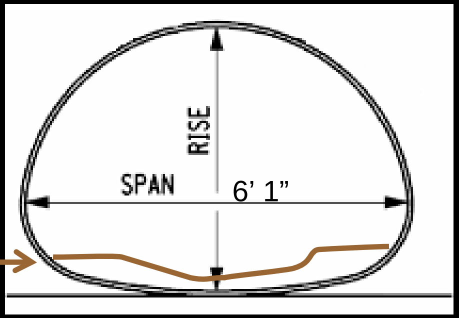
Table C (Round Culverts):

- Opening Size >= 18 sq ft = 23.75 sq ft
- Culvert Diameter = 66 in

→ Equivalent Pipe Arch = 73 in x 55 in

→ Allows Embedding (23.75 – 18 = 5.75 sq ft)

16% of opening size



Step 2 (continued)

Consider alternatives: Open Bottom Arch

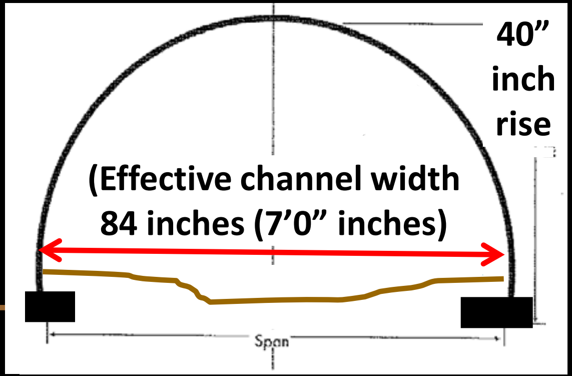
Dimensions: Span, Feet	Dimensions: Rise, Ft.-In.	Waterway Area Ft.^{2}	Rise/Span Ratio
6.0	1-10	7.9	0.30
	2-4	10.0	0.38
	3-2	15.0	0.53
7.0	2-5	12.0	0.34
	2-10	15.0	0.41
	3-8	20.0	0.52
8.0	2-11	17.0	0.36
	3-4	20.0	0.42
	4-2	26.6	0.52
9.0	2-11	19.0	0.33
	3-11	26.5	0.43

Stream-Smart Design:

3X cross section (25-year flood):
- Stream width = 6 ft
- Average stream depth = 1 ft
- Opening size = 18 sq ft

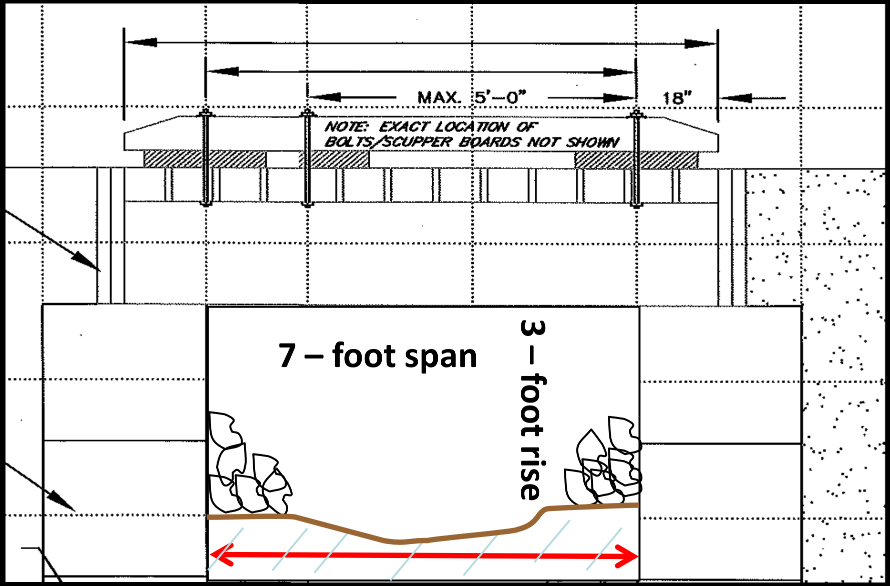
Table C (Round Culverts):
- Opening Size >= 18 sq ft = 20 sq ft
- Culvert Diameter = 66 in
- 7’ x 3’8” Open Bottom Arch

→ Allows Footer Embedding (20 – 18 = 2 sq ft)



Step 2 (continued)

Consider alternatives: Small bridge



Stream-Smart Design:

<u>3X cross section</u> (25-year flood):

Stream width = 6 ft

Average stream depth = 1 ft

Opening size = 18 sq ft

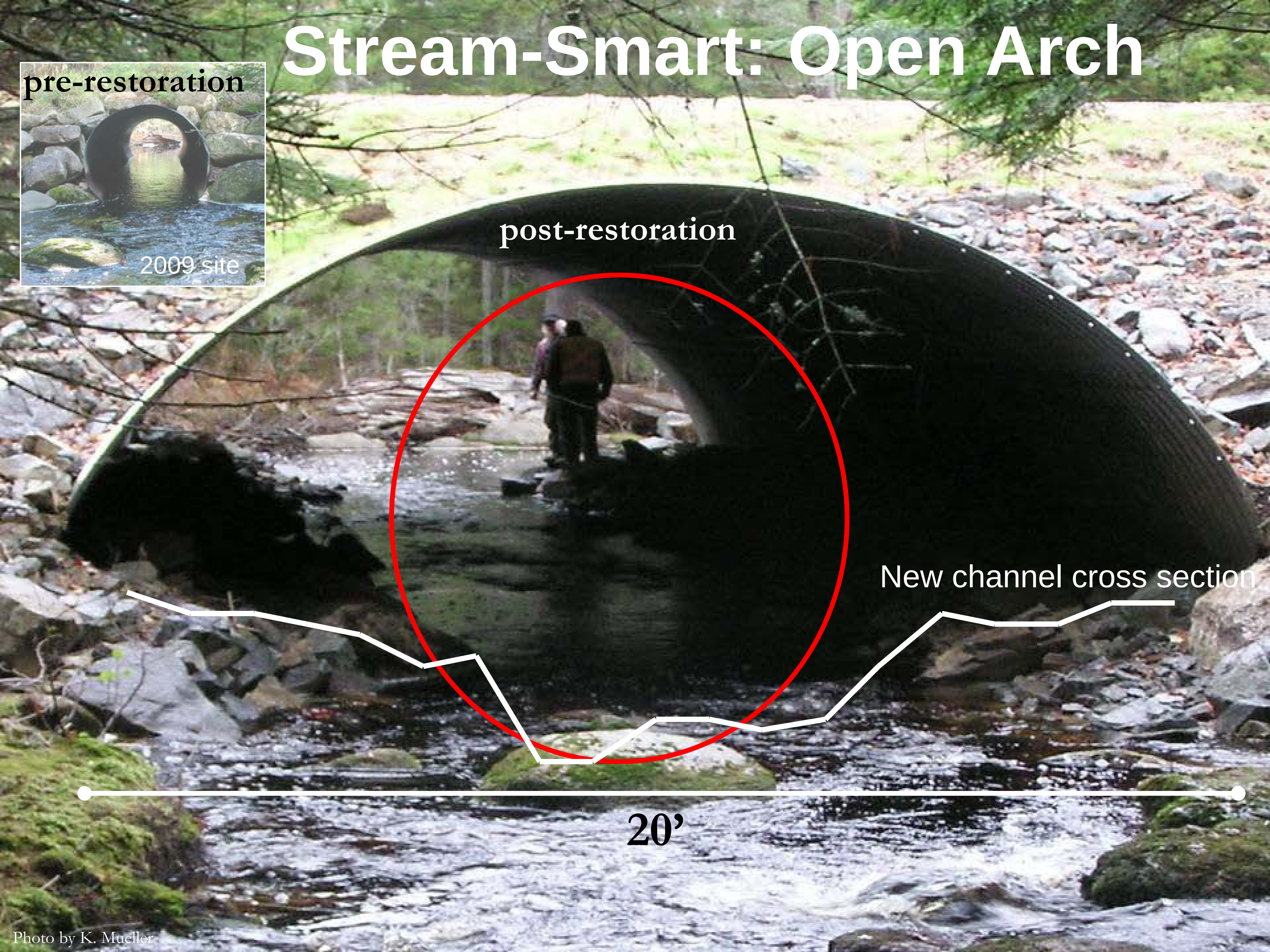
Opening Size >= 18 sq ft = 21 sq ft

Culvert Diameter = 66 in

7' x 3' Bridge

Comparison of Road-Stream Crossing Structures

Crossing Structure Type	Material	Cost	Life Span (years)	Advantages	Disadvantages
Bridge A	Steel-reinforced concrete abutments (poured in-place) and decking on steel I-beam stringers	$$$	50-75	Natural bottom, durability, snow-plowable	High cost
Bridge B	Waste-block concrete abutments with steel I-beam stringers and timber deck (possibly paved or alternate decking)	$	50-75; timber redeck 5-10	Natural bottom, low cost; simplicity	Limited abutment height; snow plowing limited
Bridge C (3-Sided Box Culvert)	Steel-reinforced concrete, galvanized steel or aluminum	$$	50-75	Natural bottom, simplicity	Weight of concrete structures can limit installation options
Open Bottom Arch	Galvanized Steel, aluminum, steel-reinforced concrete	$$	50-75	Natural bottom, ease of transport, can be low profile	Care must be taken to install and protect footings, assembly required for metal plate structures
Embedded Box Culvert	Steel-reinforced concrete, galvanized steel, aluminum	$$	50-75	Natural bottom if spans stream; variety of configurations	Must span stream and be set below stream elevation to avoid outlet perch
Embedded Pipe Arch	Galvanized steel, steel-reinforced concrete	$ - $$	20-75	Natural bottom if spans stream; wide for given volume; low cost of steel	Steel short life span; not for use with ledge
Embedded Round Pipe	Galvanized steel, plastic, steel-reinforced concrete	$	20-75	Natural bottom if spans stream; lowest cost	Limited to smaller sizes; not for use with ledge
Round Pipe (at stream grade) *Not Recommended*	Galvanized steel, plastic, steel-reinforced concrete	$	20-75	Lowest cost	Rarely adequate for fish passage (develops outlet perch); limited to smaller sizes


Stream-Smart: Open Arch
pre-restoration
2009 site
post-restoration
New channel cross section
20’
Photo by K. Mueller

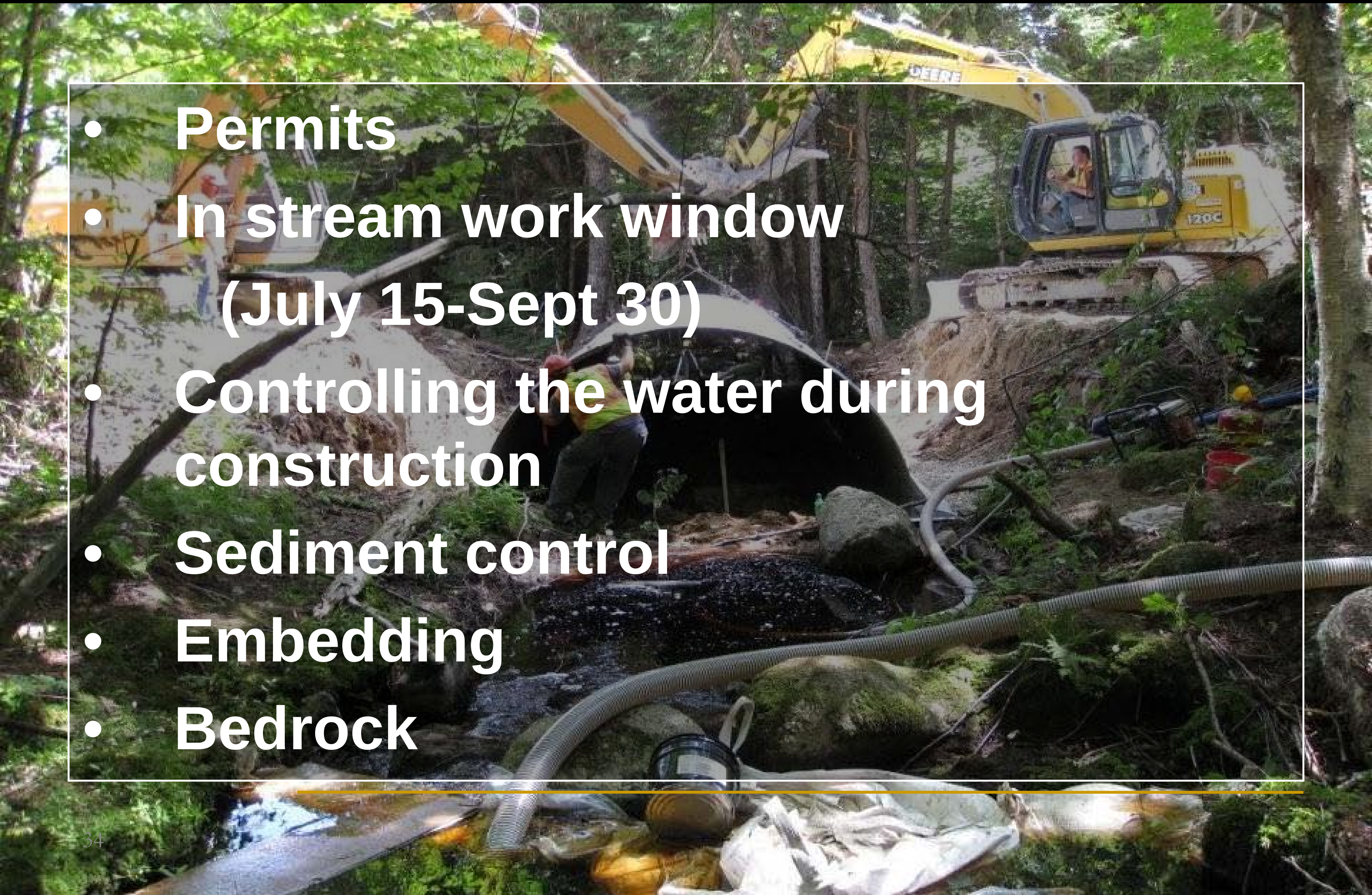
Stream-Smart:
Small bridge on low volume road

Stream-Smart:
Embedded Box Culvert

Before

After

Design & Installation Considerations



- Permits
- In stream work window
  (July 15-Sept 30)
- Controlling the water during construction
- Sediment control
- Embedding
- Bedrock

Controlling Water

When might you seek help?

- Complicated legacy effects
- When you can’t find channel
- Tidal streams
- Safety or traffic issues

Rules of Thumb (4 S's)

Span the stream

Set elevation right

Slope matches stream

Substrate in the crossing

The Golden Rule:
Let the stream act like a stream